

Clean Coal Technology and the Future of China's Environment

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INTRODUCTION

During China's pursuit for economic and technological development as a world superpower, the environment, and more specifically, China's air quality, has suffered from the processing and widespread use of coal. Currently, 70% of China's total energy consumption is from coal (Saiget, 2007). Coal has played a huge role in China's development and continues to be important in the success of the Chinese economy. Similar to the way fossil fuels powered the Industrial Revolution in the U.S, coal has fueled China's recent development due to its vast reserves. In 2006, about 2.38 billion tons of coal were mined in China and there is still an estimated 4.5 trillion tons of remaining coal reserves. This abundant energy source stabilizes China's economic growth and has helped establish the country as a major global economy and the largest consumer society (Martin, 2006). China already uses more coal than the U.S., the European Union, and Japan combined (Bradsher, 2006). The current use of coal will continue to be augmented year after year as every week to ten days a new coal power plant is built somewhere in China (Bradsher, 2006).

Unfortunately, rapid development comes at a price to the environment and the health of Chinese citizens. The Chinese government is more concerned with economic growth than environmental health because it is still a developing country and sees little incentive to spend extra capital to 'go green' (Davidson, 2007). The government is taking some steps to clean up China's air quality—motivated by the 2008 Olympics in Beijing—e.g. banning private automobile travel for two weeks prior to the Olympics start date and shutting down iron and steel plants within twenty-five miles of Beijing (Hund, 2007; Davidson, 2007). Even so, economic development comes first, as evidenced by the

last-minute postponement of the National Plan on Climate Change in April (Saiget, 2007). The very broad plan was designed to address climate change in China over the ensuing five years and would have been China's first major document on the topic (Saiget, 2007). It was allegedly postponed due to disagreements between local governments and the central government over the potential impact on the economy. Local governments are more concerned with economic health while the central government is more concerned with environmental health (Saiget, 2007).

Because China is expected to become the world's leader in GHG emissions in two to three years, passing the United States (Saiget, 2007), it is important to examine the Chinese public sentiment surrounding coal use, the barriers to action posed by the current government procedures and policies as well as the progress of public and private sector attempts to promote cleaner energy thus far.

Project Goals

As part of the Environmental Studies Senior Seminar at Middlebury College, we worked with Gretchen Hund '79 to evaluate China's current energy situation and more specifically the feasibility of successful construction of a coal-fueled, near-zero emissions power plant in China. Hund works for Battelle, one of the world's largest non-profit R&D institutions, involved with the FutureGen Alliance (www.futuregenalliance.org), an international non-profit consortium of twelve multinational coal companies working with the U.S. Department of Energy (DOE). The Alliance plans to integrate technologies available for capture and sequestration of carbon dioxide and reuse of hydrogen and other byproducts in the construction of a single test plant in the U.S. by 2012 to prove the

feasibility of building a near-zero emissions coal plant. Once this is accomplished, the Alliance plans to export its technology to other countries.

The China Huaneng Group, China's largest coal producer and one of the organizations involved in FutureGen, has created a replica of FutureGen in China called GreenGen. While GreenGen is a network, the China Huaneng Group dominates as a 95% shareholder (Hund, 2007). Because it takes quite some time to adapt an international plan and tailor it to China's needs, the formation of GreenGen is both logical and commendable (Zhang, 2007). Hund is designing and implementing the communications and stakeholder involvement strategy for the FutureGen Alliance and she is interested in GreenGen's progress with research and development, as well as the issues GreenGen could face with respect to public acceptance of coal use and barriers to action posed by government policies.

The goals of this project are to (1) Research the current energy situation in China with a focus on coal use and (2) Assess public knowledge and acceptance of cleaner coal technology.

METHODS

There is a dearth of literature addressing public acceptance of coal in China and research and development of cleaner technologies. It was necessary, therefore, to conduct interviews of players in the policy, coal and academic fields and subsequently aggregate their expert knowledge to address the project goals.

In-depth interviews over the phone or e-mail were conducted of (1) A leader of the International Cooperation Department at the China Huaneng Group, the 95% shareholder of GreenGen, (2) Casie Davidson, a geologist working for Battelle and a DOE lab, (3) a representative of the Climate Change section of Greenpeace China, (4) Mark Ginsberg of the Department of Energy's Office of Energy Efficiency and Renewable Energy Board of Directors, and (5) Randy Kritkauskys, President of ECOLOGIA. Research via literature on China's energy situation and current events surrounding coal use was also on-going throughout the semester to supplement the information gained from the interviews and provide material for follow-up questioning. Interview findings are incorporated into our background sections, and a list of interview questions and full transcripts of the responses are provided in the appendices.

A survey designed to assess the public knowledge and acceptance of coal technologies was posted to surveymonkey.com in English and distributed to university students and NGO employees through various contacts obtained through Middlebury students, alumni, and professors. It is linked to one student activism group named Green Stone, in Nanjing (<http://www.gsean.org/forum/read.php?tid=10912>). The survey (Appendix 1) first collected demographic information and then asked questions about relative knowledge of the effects of coal use, personal energy sources, personal concern

surrounding coal use and China's economy, willingness to pay for cleaner technologies, and knowledge or lack thereof of the GreenGen organization.

The survey was translated to Chinese by ChengCheng Xu of the China Working Group, a student organization at Middlebury College (Appendix 2). Unfortunately a survey program which supports Chinese characters was not found and there was no way to efficiently collect responses. However, because most Chinese students receive several years of education to learn rudimentary English, we were still able to collect sufficient responses using only the English version (Yadong, 2007).

ENVIRONMENTAL POLICY BACKGROUND

Throughout history it has been apparent that countries cannot enjoy sustained rapid growth without experiencing environmental damage. In the U.S. for example, unchecked industrial growth led to such disasters as the ignition of the chemically polluted Cuyahoga River in Cleveland, Ohio. China, which is experiencing one of the fastest growing economies in the world, has seen increased incomes, some improved health indicators, as well as reduced poverty. However, while this growth has been mostly positive for China, it has not been totally benign. Environmental pollution from coal combustion is damaging to human health, air and water quality, agriculture, and ultimately the economy (eia.doe.gov). When taking steps to protect the environment and reduce greenhouse gases, China first asks if the decision will reduce economic growth. For example, China signed the Kyoto Protocol, but refuses to accept mandatory cuts in emissions, arguing it will have an impact on economic development (Griffiths, 2007). For decades, Chinese politicians have placed the economy ahead of the environment. Chinese President Hu Jintao now faces the dilemma of translating concern for the environment into policies that deliver growth and jobs while cutting fossil fuel use and greenhouse gases. “It is dawning on China that they will not continue growing like this unless they deal with climate change” (Griffiths, 2007).

Since the 1970s, legislation and institutions to protect China’s environment have been created. Beginning in 1972, Chinese officials attended the First United Nations Conference on the Human Environment in Sweden, which initiated the dialogue surrounding environmental protection in China. The next year, China created the Environmental Protection Leading Group to concentrate on—and research—

environmental issues, and in 1983 the Chinese government established a state policy declaring environmental protection. After a disastrous year of flooding in 1988, the Chinese government advanced the position of the Leading Group to a ministry-level agency, which is now known as the State Environmental Protection Administration (SEPA) (english.sepa.gov; eia.doe.gov). The role of SEPA is to regulate water quality, ambient air quality, solid waste, and radioactivity. SEPA is also responsible for publicizing national environmental policy and regulations, collecting data, and providing technological advice on national and international environmental issues (english.sepa.gov). In 2006, SEPA opened five regional centers throughout the country to assist with local inspections and enforcement.

Furthermore, in 1992, Chinese officials attended the Conference on Environment and Development (The Rio Declaration), which recommended that each nation create an agenda for the twenty-first century. After this conference the Chinese government began the process of formulating China's Agenda 21, which was completed and adopted in 1994. Agenda 21 is based on China's specific national conditions, and gives consideration to population, environment, and development, while setting up a strategic goal of sustainable development that can promote coordinated development of economy, society, resources, and the environment (UNESCAP, 1997). Another environmental protection measure adopted by China is the Energy Conservation Law, which was adopted by the Standing Committee of the National People's Congress on November 1, 1997. The Energy Conservation Law was formulated with a view of facilitating energy savings throughout society, improving efficiency and economic benefits of energy use,

and protecting the environment. In this context, energy refers to coal, crude oil, natural gas, electricity, coke, coal gas, thermal power, etc. (UNESCAP, 1997).

Many people, however, maintain that environmental enforcement from SEPA officials remains rather relaxed or non-existent. It is greatly understaffed, with 300 officials in Beijing and 100 more for the five regional offices, which means that monitoring and enforcement generally fall to local officials, or even factory managers—whose first priority is to create jobs (china.org). For example, even where waste-treatment facilities are installed, many Chinese companies opt to pay fines rather than operate the equipment. The cost of cleaning up waste water can reach \$600 per 1000 cubic meters, while the penalties are only \$499 per 1000 cubic meters (Balfour, 2005). This is a perfect example of the mixed messages SEPA is sending to the businesses of China. Further, since economic growth takes precedence, China is placing a higher value on business success than on citizen health.

In an e-mail interview with Mark Ginsberg from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy Board of Directors, he expressed that the enforcement of any environmental regulations or protocols in China will vary widely from locality to locality, and from province to province. He explained that in the relatively impoverished province of Shanxi, for example, the sky has been darkened for decades due in large part to the production of coke—a byproduct of coal—in very small, unregulated, local backyard coke kilns. It is very difficult for the central government to collect taxes from localities, so one can imagine the difficulties in getting local officials to crack down on one of the few things that can earn badly needed income in a poor province with large amounts of sulfur coal resources (Ginsberg, 2007).

Pan Yue, deputy director of SEPA has been one of the most critical high-level officials in the Chinese government working on their current development model. In an interview with China Daily about the global environmental crisis, Yue claims that “The fundamental cause is the capitalist system. The environmental crisis has become a new means of transferring the economic crisis” (Jigang, 2006). Yue’s biggest concern is that “In 20 years, China has achieved economic results that took a century to attain in the west. But we [China] have also concentrated a century’s worth of environmental issues into those 20 years. While becoming the world leader in GDP growth and foreign investment, we have also become the world’s number one consumer of coal, oil and steel—and the largest producer of CO₂ and chemical oxygen demand (COD) emissions” (Jigang, 2006).

Local environmental boards that are responsible for promoting measures to protect the environment come under local authority. Given a factory manager’s overriding objective for profit and increasing income and tax revenue for the local authorities, environmental considerations usually land low on their list of priorities. According to Chinese environmental authorities, state-owned enterprises usually produce less waste than township and village enterprises. Village enterprises create more industrial pollution and almost all of this waste is dumped indiscriminately. Many of these enterprises are highly polluting industries that dump heavy metals, dyes, and other poisonous substances in rivers and lakes. Village enterprises are also warned in advance about impending inspections so they may stop polluting temporarily or flush out waste pipes with clean water to pass emissions tests (Ross, 1992).

Despite limitations, China has made progress on several fronts. In 1999, through an effort to reduce air pollution in Beijing, the local officials required all city vehicles to convert to liquefied petroleum gas and natural gas. By 2002, Beijing had 1,630 natural gas vehicles, the largest fleet in the world (eia.doe.gov). In 2006, Fiat provided 1,000 natural gas engines for buses in Beijing, which reveals that the effort did not dissipate, and that things are being done to curb pollution (greencarcongress.com). Also, in 2002, China enacted the Cleaner Production Law, which established demonstration programs for pollution remediation in ten major Chinese cities, and designated several river valleys as priority areas (eia.doe.gov).

While some governmental efforts to reduce pollution have been successful, China's environmental policies tend to look better on paper than in reality. Just a month ago, Chinese officials delayed the release of a highly anticipated national 'action plan' on climate change, which was to discuss how China should manage greenhouse gases and other pollutants that contribute to global warming. The government did not offer any explanation as to why the release of this plan was delayed, nor did they offer a timeline of when they expect to release this plan (Greenwire, 2007). Chinese officials are aware that climate change and pollution could become major constraints on national economic development. Many policymakers believe it is imperative to have a comprehensive national plan to serve as a fundamental base for them to deal with climate change (Griffiths, 2007).

It is clear that China's leaders are caught between economic development on the one hand and environmental protection on the other. Between 2001 and 2005, SEPA received 2.53 million letters and 430,000 visits by 597,000 petitioners seeking

environmental justice, and in 2005 there were over 51,000 disputes over environmental pollution (sepa.gov). Clearly there is concern from within China to improve the environmental situation. There is not a lack of environmental policy in China, but there is a lack of desire and accountability to enforce and regulate these policies. President Hu Jintao is faced with the dilemma of translating concern into policies that deliver growth and jobs while cutting fossil fuel use and greenhouse gases, and it is imperative that these policies are established in a timely manner.

PUBLIC HEALTH ISSUES

In early April of last year an American satellite spotted an image of a dark cloud-like figure moving eastward across the Pacific ocean towards the U.S. west coast. Meteorologists thought that perhaps it was a strange storm front that was somehow discolored from some sort of chemical reaction, but upon closer inspection were shocked to learn the true identity of this nebulous mass. It was a dense cloud of pollution, darkened by the soot that invades the air in Northern China. It finally occurred to the world that the dirty coal-powered energy plants that define the Chinese economy were beginning to affect the entire globe, and not just the Asian continent.

Historically, China has been linked to images of a picturesque landscape defined by unique species that would come to shape the culture of the people. Throughout the modernization of the land, the forests were cleared for their wood so that energy could be created. However, the land was deforested much too rapidly to be a sustainable source of fuel, and therefore another alternative was found—coal. It was impossible to predict the ramifications of coal combustion, and now carbon emissions around the globe are out of control. China's exploding population and economy demanded an increase in energy production. The beginning of the industrial revolution was a very productive time for coal-fueled power plants because the mining process and labor were so cheap. Western companies took advantage of this cheap cost of work in China and exported many goods so that they could be assembled and then sent back. The familiar tag "Made in China" has become a household term throughout the last few decades. Because of the fast rate of production, China's black-gold fueled economy has grown at the steady rate of 10 percent in the last three years alone. This was enough to put China second on the list for

world's largest exporter, just behind Germany and just in front of the United States (Hill, 2007).

China's rapidly growing population must also be held responsible for the high levels of greenhouse gas emissions and consumption. Since the 1970s, the one-child policy has limited the number of children families are allowed to have. This has not been strictly enforced and therefore casually followed, creating inaccurate census information year after year. Families have only legally claimed one child in their family, while there are numerous unaccounted for children in schools and homes (news.bbc.co.uk, 2001). There are many reasons for the environmental crisis in China, but the population and growing economy have played a major role in pressuring the coal industry to produce more than the atmosphere can handle. Today, more than 70 percent of China's energy is derived from coal-burning plants, and this number continues to increase as the demand for electricity grows.

Chinese government has been reluctant to reduce coal consumption and greenhouse gas emissions because the people are so dependent on cheap energy. A family living in Shanghai can pay \$2.50/month for electricity produced by a nearby power plant. This family may have formerly lived in a straw hut in a hillside village with no running water or electricity (Bradsher, 2006). These families live off of a \$25 a month salary, eating little but rice and vegetables. For many of these families, the black soot clouds in which they work and play are an acceptable sacrifice for a hearty meal, electricity, or a warm bed at night. Since China is still very much so considered a developing country it is difficult to place blame on their efforts to grow and expand. In so many circumstances it would be detrimental to the country to cut the production of coal. However, their success

has now become a global problem that is affecting many people beyond the borders of the republic. The pollution has begun to take its toll on bordering countries such as South Korea and Japan, as well as the ocean waters close to the Chinese coastline. The emissions of harmful greenhouse gases that contribute to the problem of global climate change are not the only consequence of burning coal. Acid rain now falls on more than 30% of China, destroying forests and poisoning lakes. High arsenic levels in crops and mercury poisoning in fish has impacted farmers and fisherman alike. Not only has this pollution decreased production, but has jeopardized the health of those people who consume the food. Although there have been efforts to use alternate energy sources in the last few years, the warming of the climate has caused a major problem for the hydro-power plants because of the quick evaporation rate. Most of the rivers are useless for electricity because the current has slowed down so much, and many lakes throughout the country have completely dried up.

Although the Chinese government is aware of the environmental impacts of coal-burning emissions, the main concern should be for the well-being of its people. The health implications of coal combustion are often ignored because people in the United States are not victims of such detrimental consequences. Toxic substances emitted into the air from coal burning have dramatically affected human health in China for the last few decades. The harmful emissions have accounted for nearly 400,000 premature deaths per year (Bradsher, 2006). For example, a disease called chronic obstructive pulmonary disease (COPD), linked to exposure of fine particulates such as sulfur dioxides, accounted for 26% of all deaths in China in 1988 (Finkelman, 1999). This same disease in the United States is linked to exposure to cigarette smoke. However, China's death rate

related to COPD is still five times higher than the U.S.'s cigarette-smoke related deaths. In addition, pulmonary disease and strokes have increased in Chinese people because of the exposure to indoor emissions from poor-quality coal used for cooking and heating (american.edu/chinacoal.htm). The burning of coal in China has been directly linked to these diseases as well as many types of cancer, lung disease, and heart disease. The environmental state of China is desperate for change, especially in light of the upcoming Summer Olympic Games in Beijing. Many international athletes are worried that the air quality is too hazardous to compete in; especially concerned are track and field athletes and marathon runners. Some officials have suggested that the roads of Beijing be closed to all automobiles for two weeks before the Olympics. This may help clear some of the smog, but certainly won't be able to improve the air quality long enough to benefit Chinese citizens as well as Olympics visitors. In some places such as Shanxi Province, the air is so cloudy and darkened with soot that people have been forced to drive with their high beams on during the lightest hours of the day.

Even more sobering statistics are linked to coal mine accidents throughout China. Last year alone 4,746 people were killed while on the job. In China, it is simply an accepted consequence of the job that mining is dangerous—a small price to pay for some since the pay is so good. “Injury or death is inevitable to us miners. It is just a matter of luck and whose turn it is. As time passes by, I have nothing on my mind but digging out more coal to get more money,” coal miner Xiao Zhihai, 47, told the student investigators, China Youth Daily reported (Zeng, 2007). The exposed mountain top coal mines are an accident waiting to happen, and it seems that nothing has been done to improve the safety of the process. According to a *New York Times* article written in June of last year, “every

week to ten days, another coal-fired power plant opens somewhere in China that is big enough to serve all the households in Dallas or San Diego” (Bradsher, 2006). This figure is startling not only because of the rapid production, but because the serious environmental and health impacts of coal burning are being ignored.

Several other countries have recognized the problem and have offered to help China develop new technology that is cleaner and more efficient. Japan has fallen victim to the dirty ways of the Chinese and has finally had enough of the acid rain that continues to fall on its land. The Japanese government has offered \$125 million for “desulfurization” technology to be spread throughout China. The sulfur filter will eliminate up to 95% of sulfur emission from every coal plant in China. Most western coal power plants have already installed this technology, and China hopes to have filters in plants by the year 2010 (Bradsher, 2006). Another large grant has come from the World Bank in 2003, to help promote the addition of new IGCC (integrated gasification combined combustion) clean-coal technology. The \$15 million will go towards creating new near-zero emissions technology that uses a new “gasification” process. Although this will be a lengthy process, the change will certainly improve the air quality of China, and beyond.

CLEAN COAL TECHNOLOGY

Currently, about 70% of China's electricity is generated by burning coal (Saiget, 2007). China already uses more coal than the U.S., the European Union, and Japan combined (Bradsher, 2006). In 2006, about 2.38 billion tons of coal were mined in China and there is still an estimated 4.5 trillion tons of remaining coal reserves. With the coal plants now in use in China, the process is very inefficient and harmful to the environment. It is estimated that every week to ten days another coal power plant opens somewhere in China that has a large enough capacity to serve all of the houses in Dallas or San Diego (Bradsher, 2006). The combination of the tremendous reserves of coal in China, the dirty, inefficient power plants currently in use, and the increase in number of these power plants is a recipe for disaster. China *will* use its coal reserves because of the ever-increasing demand for energy associated with Chinese economic development. Finding a *cleaner way* to convert Chinese coal into electricity is imperative if China hopes to develop in a reasonably environmentally friendly manner.

The FutureGen Alliance

In order to use coal as a fuel source in a more environmentally friendly way, The FutureGen Alliance is currently developing a newly designed "zero-emission" coal-fueled power plant. FutureGen is responsible for the design, construction and operation of the facility. It will use cutting edge technology that not only gasifies coal and generates electricity, but also prevents other pollutants from being emitted (such as sulfur), captures and sequesters carbon dioxide, and produces hydrogen gas at a commercial scale that can be used for industrial purposes, fuel cell applications, or further electricity production (Figure 1).

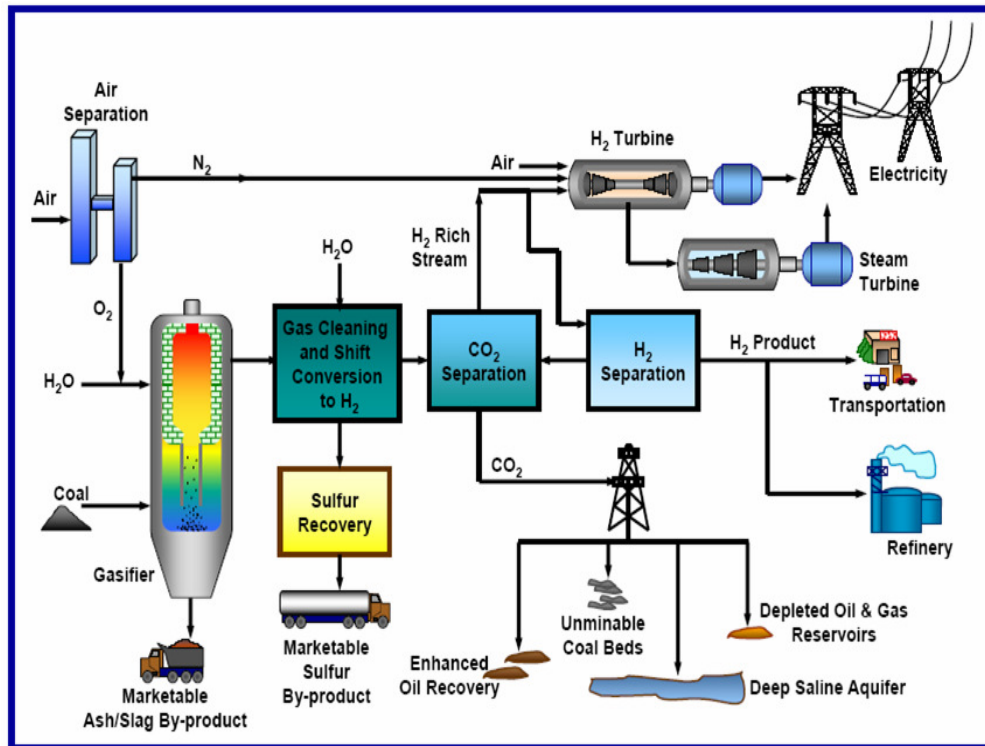


Figure 1: This diagram illustrates the integrated steps of FutureGen's new power plant (Source: U.S. Department of Energy).

FutureGen plans to have the technology for this new power plant ready by 2008 and have an operable plant by 2012. As of now, they have not specifically laid out efficiency targets for the plant, but the Alliance aims to set the efficiency as high as possible, which will definitely be more efficient than traditional existing coal plants. Unfortunately, the process of capturing the carbon dioxide reduces the overall efficiency of the plant, but this must be overlooked because of its huge benefit in lowering the emissions of the plant. FutureGen explains, "Part of the learning that will come from operating this first-of-its-kind facility is whether electricity production combined with CO₂ capture and sequestration can be done efficiently and cost effectively" (FutureGen, 2006). Because this power plant will be a research and development facility and will test out a variety of coal types, the efficiency metrics used for traditional power plants are not necessarily relevant.

Out of all the new technology combined within this one power plant, most concern is related to the sequestration and monitoring of the carbon dioxide captured from the gasified coal. People frequently ask about the type of geologic formation that will be used to store the CO₂, the storage capacity of these formations, and the risk of the CO₂ leaking back into the atmosphere. The FutureGen Alliance has consulted experts in geology and carbon sequestration about these issues and has found viable possibilities to make carbon sequestration a realistic goal.

To answer the first question, geologists have found that deep saline formations, at depths greater than 3000 feet, are the target formation for CO₂ storage (FutureGen, 2006). These formations are seen as ideal because they possess large carbon dioxide storage capacities, making them a long-term viable solution. These deep saline reservoirs are widespread and are conveniently located near many of the proposed sites for FutureGen's power plant. FutureGen (2006) describes, "Because the Alliance wants to ensure that FutureGen is broadly replicable around the U.S. and the world, it is important to demonstrate CO₂ sequestration in this more widely occurring type of formation."

Not only are these deep saline formations widespread, but they also have the potential to meet the expected storage capacity of a FutureGen power plant. FutureGen estimates that it will inject a minimum of 1 and up to 2.5 million tons of CO₂ per year. To accommodate the relative lifespan of a power plant, the Alliance is looking for sites that have the capacity to handle at least 50 million tons of CO₂. This figure has become one of the many criteria used to evaluate potential FutureGen sites.

Because FutureGen is looking to build its first power plant in the United States, it gathered an international panel of independent experts to evaluate 12 proposed sites

across the country. This panel created a list of over 100 extremely strict criteria based on a subsurface geology and power plant siting perspective, and was able to narrow the 12 proposed sites down to 4. As mentioned above, storage capacity is an important criteria—the geological experts determined that the storage capacity of these 4 sites exceed the minimum standard, making them extremely attractive options. Using seismic information, the geologists have also concluded that these potential sites did not have any faults that cut through the target geologic formation or the overlying caprocks that are necessary for containing the CO₂. These sites are large enough and will safely contain the CO₂.

One of the most important aspects of this new technology to consider is all of the monitoring that will occur after the power plant is built. FutureGen states, “After the CO₂ is injected, we will continue to monitor the CO₂ plume by conducting periodic surveys with a sophisticated measuring, monitoring, and verification protocol to assess the behavior of the CO₂ in the storage formation.” This decreases the amount of risk associated with the new technology. Even with monitoring, there are very few safety concerns because CO₂ is not toxic. In regards to a common concern about the sequestered CO₂ and its relationship to groundwater, the geologists have stated that groundwater is at very shallow depths compared to where the storage formations are found. They describe that depending on which site is chosen there would be hundreds or thousands of feet of rock separating the two, as well as multiple impermeable seals or caprocks between the target formation and overlying formations (FutureGen, 2006).

GreenGen

While FutureGen plans to combine integrated gasification combined combustion (IGCC), hydrogen production, and sequestration technology in one plant, GreenGen has the same goals but is dividing them up into 3 stages. GreenGen is a non-profit that is providing/developing the technology for this pilot project in China. GreenGen is funded primarily by the China Huaneng Group, which is one of the top ten power companies in the world, one of the largest coal companies in China, and also a leading member of the FutureGen Alliance. Chinese research institutes are designing the technology because GreenGen feels it is less expensive for China to develop its own technology than to buy international technology. They plan to develop their gasification technology by 2010 and their carbon sequestration technology by 2015. They are unsure whether they will also attempt to produce hydrogen gas from this process.

Like FutureGen, GreenGen also plans on using deep, saline formations to eventually sequester the carbon dioxide produced from the coal power plants in China. While this step in the process will not be ready in China until 2015, geologist Casie Davidson shared with us in our interview that the storage capacity within the geological formations, specifically the deep, saline formations, in China looks promising, as there are “quite a few” viable formations throughout China large enough to meet capacity necessities. Davidson spent a week in China researching the CO₂ storage capacity within the geologic formations of China. She worked with a partner from the Institute of Rock and Soil Mechanics in Wuhan who has done a lot of research in the literature about the Chinese saline formations. However, the problem in China is that there is not a lot of

published data. The geologic data that are available are from petroleum companies, but “it is very scattered and it is the luck of the draw if you find it” (Davidson, 2007).

Davidson has found that there is a bit of a mismatch between where the deep, saline formations are located and where the most CO₂ is produced (by coal power plants and other industry), and even if a power plant is sitting on top of one of these deep saline formations, it might not be the best place to inject the CO₂. This mismatch is actually quite common and it has become normal to use pipelines to transport the CO₂ to a better formation. It is very rare to put a CO₂ well right next to the power plant, unless you are really lucky in regards to the underlying formations.

An example of this mismatch is seen in the northwestern region of China where there are plenty of CO₂ storage formations, but hardly any sources of CO₂ from power plants. There are so few coal power plants because their processors require large amounts of water, yet water is very scarce in this region. Davidson explained, “You could never put one of these industrial processors there [the northwest region] because the very little water that is in this region is used for drinking and irrigation” (Davidson, 2007). Even more advanced technology to use dry cooling or something to conserve the water resources would be needed. With dry cooling technology, northwest China would be a good place to have a power plant and CO₂ storage right next to each other, then transmitting the power where it is needed. However, right now it looks as if northwest China might be a resource that won’t be tapped for quite some time because there are no power plants generating CO₂ there (Davidson, 2007). Overall, Davidson concluded, “China has **most** of what it needs in **most** of the right places. For anything not in the right place, pipelines can be used” (Davidson, 2007).

Another solution to the water scarcity problem involves using waste water. FutureGen is likely to demonstrate that waste water can be used in the U.S. (2 of its 4 planned sites would use waste water). This waste water used would be sewage water that has been treated and put back out and is actually clean enough to drink. Davidson explains that the waste water option is being looked into more and more as water resources are declining, especially in places where a high percentage of ground water is being used for drinking and irrigation. She thinks it is a good idea because once it is treated, it can be used it for something productive instead of just putting it back into the ground.

Waste water is a likely potential for the U.S. because water treatment standards are very high. Water quality in China, however, is not held to the same high standard. In Beijing, for example, often even regular water is not drinkable. Davidson commented, “Using waste water in a city like Beijing may not be as simple as using waste water in the U.S. (our waste water may be cleaner than their drinking water)” (Davidson, 2007). Hence, while using waste water is a promising idea, it may not be as feasible in China as it is in the U.S.. Davidson’s final opinion on the matter is that people doing energy work in China and people doing water work are going to need to start working together in order for developments to be made in the near future.

SURVEY RESULTS

There is little literature on citizen perception of coal use beyond their reactions to health implications, the Olympics, and mining accidents. As with most innovative projects concerning the environment, it is difficult to predict public opinion. For these reasons a survey was conducted to generate data on public opinion. One of the key factors determining the success of a new technology is public acceptance. Public awareness and perception of carbon capture and storage technologies in China is may play a role in government policies, industry interest in building and innovating cleaner technologies, investor interest and support of these endeavors, and the public willingness to live near sequestration sites and pay for more expensive cleaner energy. Public opposition can delay or even halt progress if steps are not taken to understand the public stance and plan education campaigns. It is difficult to predict public acceptance using proxies such as the interests of elected officials because of the difference in risk preferences for citizens and public officials, and varying familiarity with the technology (Huijits, 2007). Knowledge of carbon capture and storage (CCS) in China is minimal and there is little material written for the general public to explain the technology. Therefore, to prevent the survey from being intimidating or overly time consuming, our survey questions focus not on acceptance of CCS, but on general feelings about coal and willingness to pay for cleaner technology (Appendix 1).

The online survey collected 30 responses from current and previous residents of China. Participants ranged in age from 19-58 and hail from Wuhan, Beijing, Shanghai, Shan Dong, Suzhou, Chong Qing, and Tianjin. Almost half the respondents are from urban areas with the rest in either suburban or rural areas. Twenty of the 30 participants

are university students studying a range of topics. Of the 10 with careers, only 3 are environmentally related. The response pool is dominated by university students, which reflects the survey distribution methods (e.g. facebook.com groups, contacts through study-abroad programs with Middlebury in China). It is expected that personal circumstances, such as knowing someone in the coal industry, could affect one's view on coal issues (Davidson, 2007), therefore the fact that only 20% of the respondents knew someone in the coal industry suggests that there is little bias for or against cleaner coal technology derived from family involvement in the industry. Full survey results are shared in Appendix 3, while some of the major themes are discussed below.

Respondents use a range of energy sources including coal, oil, gas, nuclear and solar energy but half of them are unsure what their energy source is because it comes from the national electric grid (Figure 2). It is possible that these results actually represent a 61% coal energy source but the definite energy source for the national electric grid is unknown.

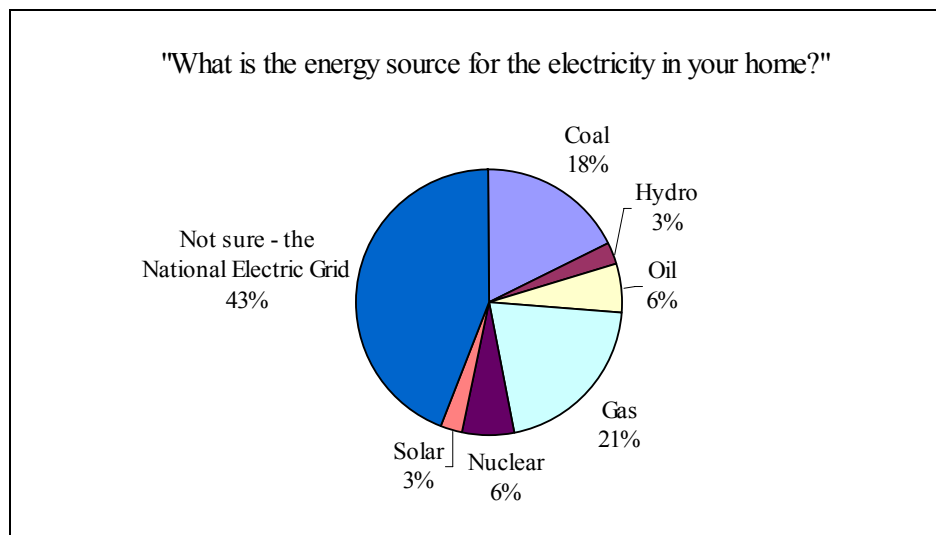


Figure 2: Energy sources for 30 survey participants.

The participants consider themselves somewhat informed about the effects of coal use on climate change (69.2%), they associate it with air pollution and acid rain (89.7%), feel they understand the effect of humans on global climate change in general (86.2%, 4 not sure), and are somewhat informed about the specifics (60%, 36% very knowledgeable).

More people strongly agreed with the statement that they were concerned about the role of energy in China's *future* (69%) than with the role of energy in China's *economic growth* (58.6%). This suggests that responses to the former may have more to do with environmental and health effects than economic effects. Indeed, 48% of respondents cited a "moral obligation to reduce greenhouse gases" and 36% claimed "concern about health effects from traditional coal" as their primary motivations for switching to cleaner technologies if they were presented with the opportunity to do so (Figure 3).

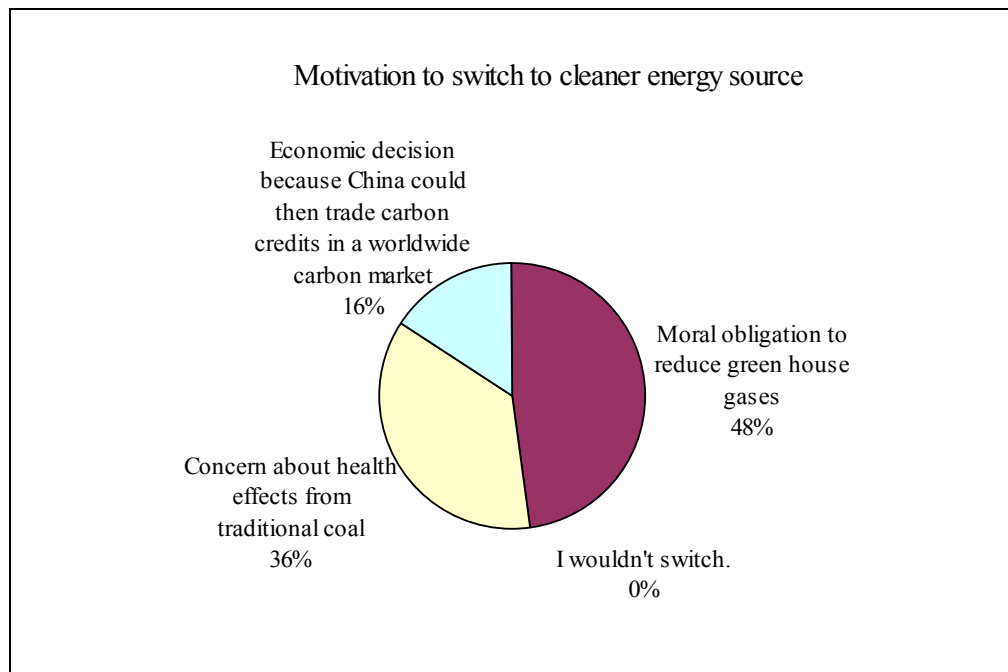


Figure 3: Motivations to switch to cleaner energy sources

It is interesting that though respondents are very concerned about the role of energy in China's future and economic growth, when asked specifically about the effect of coal use on global climate change, answers split between 'very concerned' and 'concerned' to a degree not seen between 'strongly agree' and 'agree' in questions about China's economic growth and future (Figure 4). This may reflect bias in the wording of the question but it could potentially suggest a greater concern for more immediate effects of coal use on local air quality and economic growth as opposed to global climate change. Because China is a developing country this split would be appropriate since it is typically not until a base-level of affluence is secured that residents begin to worry about issues facing the global community.

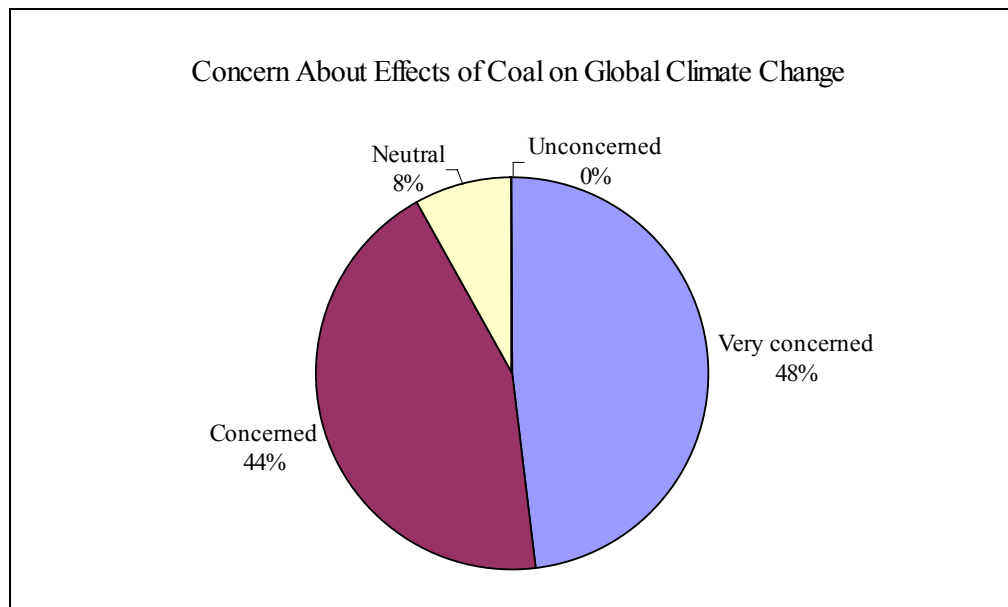


Figure 4: Concern about effects of coal on global climate change

Generally, concern for the role of energy in China's future and concern for mining issues are high (69% and 65.5%, respectively) but not as high as for the impact of *emissions* from coal use (75.9%). These results suggest that if cleaner coal technologies

were available to assuage the impact of emissions, they would ease the minds of the public. Indeed, questions about willingness to pay for such technologies reveal that all would switch to cleaner coal technology if given the opportunity to do in a cost-effective manner, particularly if they saw successful implementation in another country (92%) and if it were under state control (45.8%). By comparison, only 56% were likely to switch to alternative cleaner energy sources (e.g. small scale methane production, hydro power, solar energy) if given the opportunity to cost-effectively do so, and 2 said it is unlikely they would do so.

About half the respondents (52%) are willing to pay up to a 5-10% increase on their energy bill for cleaner coal technology (Figure 5). It is interesting to note that they do not think their parents would be willing to pay as much (Figure 6). Similar willingness-to-pay results were obtained for alternative energies (58.3% would pay 5-10%, 26.1% of parents would likely pay none and 26.1% would likely pay 5-10%).

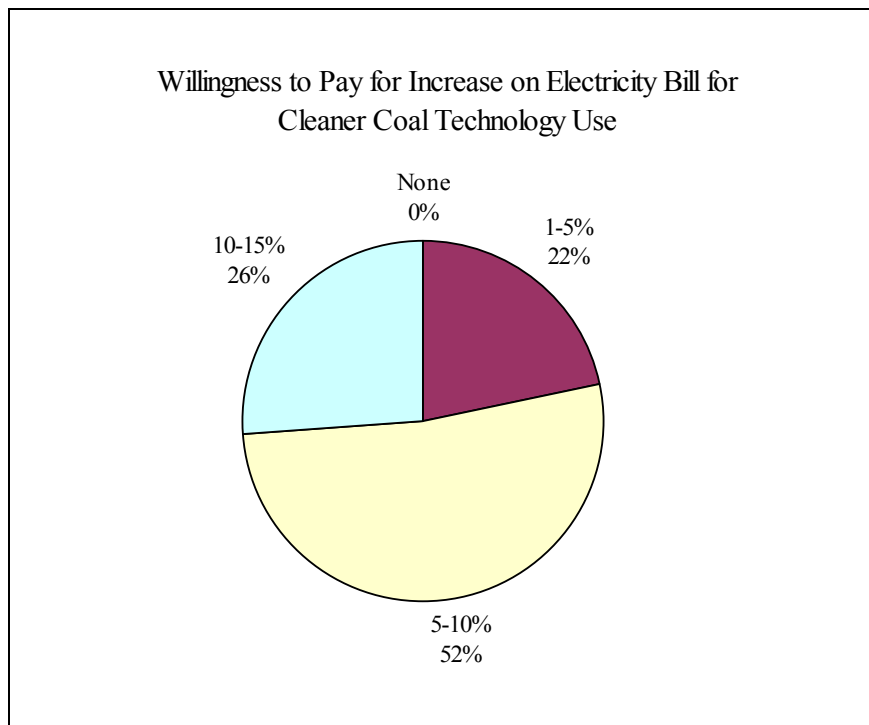


Figure 5: Willingness to pay for cleaner coal technology

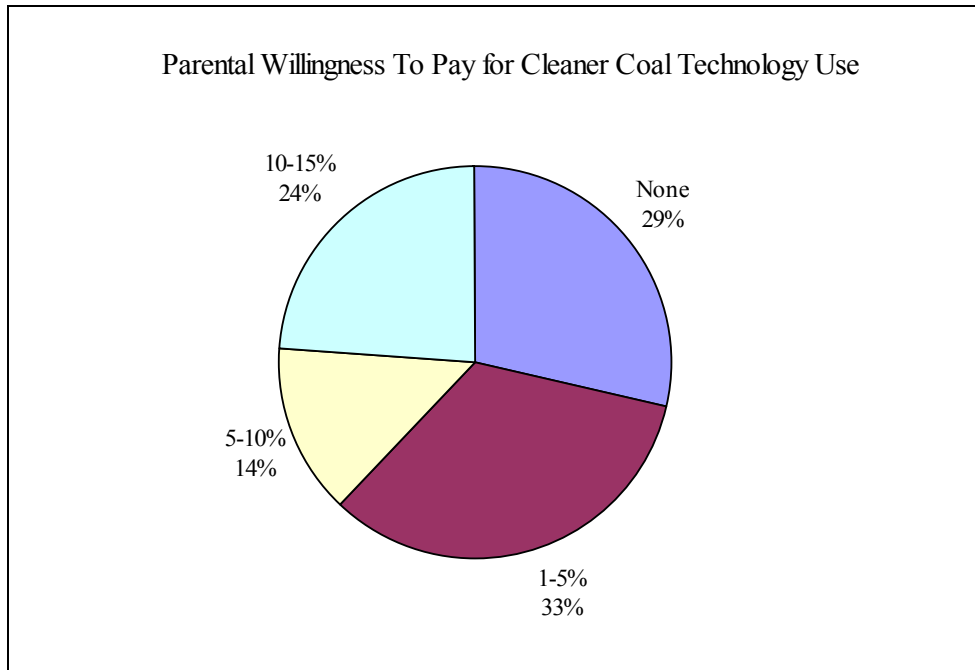


Figure 6: Perceived parental willingness to pay for cleaner coal technology

They are generally aware of China's dependence on coal (76% were aware that 70% of China's energy comes coal) and also feel an urgency to switch to cleaner sources (92%). They feel the health effects of coal are very significant (68%) and that China's management of coal use could use improvement (56%) while 8% approved and 36% disapproved of China's coal use.

One of the 30 respondents had heard of GreenGen, through word of mouth. Overall, respondents were optimistic about the potential work of the GreenGen organization with only 16% not optimistic and 28% neutral to the possibility (Figure 7).

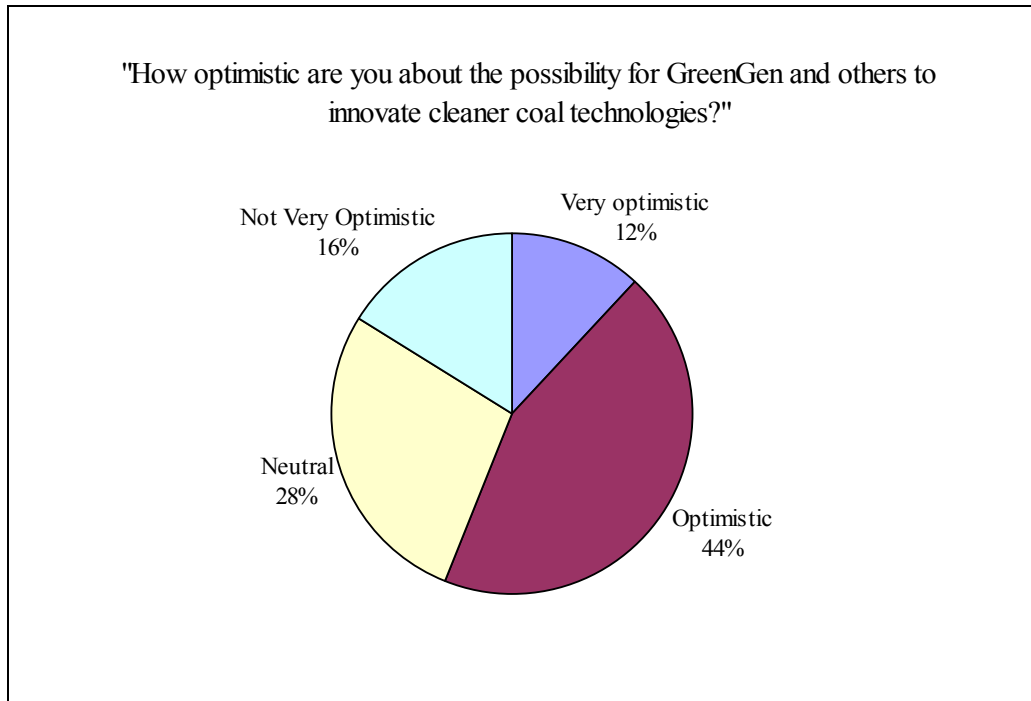


Figure 7: Optimism for the work of GreenGen

It is not unusual that none of the respondents knew about GreenGen, only a handful of “modeling geeks” from Tsinghua University in Beijing are expected to know about it (Davidson, 2007). These students also know about FutureGen because all the information is on a website and made public, whereas there is little information on GreenGen available, likely because the electricity companies involved are working closely with the government and therefore cannot share much (Davidson, 2007).

Huijts et al., (2007) discuss the social aspect of public acceptance of carbon capture and storage (CCS) technology, saying that opinion is heavily influenced by the information available and trust in industry and government. In cases where a complete understanding is not possible, one relies on trust to determine tolerance for uncertainty and overall acceptance. A survey of citizens in the Netherlands that live near a proposed site for CCS reveals slightly positive feelings for CCS but slightly negative feelings for its establishment in their backyard (Huijts, 2007). The survey also revealed that

participants trusted environmental NGOs more than government or industry officials due to their perceived competency and intentions (Huijts, 2007). In the present study, however, participants were most likely to support implementation of new technology under state control (45.8%) as opposed to private industry (25%) or coordinated international efforts (20.8%). This difference may stem from the differences in perception of the government's competence in a constitutional monarchy (Netherlands) and a communist state (China). The Huijts study also found that minimal detail on the technology and more detail on the credibility of the actors behind the technology and emphasizing the common qualities and beliefs held by officials and citizens is the key to improving public acceptance (2007).

The results of the present study have several important implications for the work of GreenGen. First of all, it appears that most citizens have some background knowledge on the harmful effects of coal combustion on the environment and are generally optimistic about the potential for cleaner coal technology to ease the impact of China's booming economy. The hardest part, creating awareness of the problem and conveying its immediacy, is completed. It appears, therefore, that if GreenGen wants to ensure success of its first project it should educate citizens using basic information on the technology coupled with propaganda outlining the experience and credibility of the alliance—especially since citizens may be suspicious of efforts to clean the environment stemming from the current record of private industry. Highlighting the safety of the technology, the expected improvements to air quality and the involvement of credible industrial and government leaders should improve the already positive public acceptance of cleaner coal technologies.

SYNTHESIS

Due to the existence of hierarchal governments at the global level, the government sector could be a powerful tool in ultimately achieving positive environmental change by being able to take advantage of their authority to set new standards, while supporting smaller private businesses, NGOs, and other environmental initiatives within smaller communities. Governments also have more influence and clout in larger global organizations like the UN, and can further develop and influence environmental change on larger scales and partake in global environmental partnerships. China used its power to secure the 2008 Olympics and could potentially make a statement about global warming by how they prepare for the Olympics and cope with their pollution problem in front of a global audience.

Social entrepreneurs, innovative people who seek positive social, environmental, and economic changes by creating businesses for the global good will play roles in pioneering solutions to climate change and other environmental problems in China. These social entrepreneurs will incorporate *metis*, also known as local knowledge, in their ideas and solutions, and will ultimately play a pivotal role in setting an example for larger governments, like China's.

If local governments worked closely with local social entrepreneurs and organizations on small-scale projects and if larger organizations and groups worked in conjunction with the federal government on problems which address both domestic and global problems, both groups would be more successful in achieving their goals. However, in China, laws that get passed are not always enforced which discourages grassroot initiatives and environmental action in general. In theory, grassroots

organizations and social entrepreneurs could thrive with economic support from the government. If this partnership results in success, achievements could be incorporated into permanent legislation.

Although certain governments may differ in structure and legislative ideals, future governments will need to partake in a “global synthesis” of ideas where metis can be shared to solve environmental problems. China is actively consuming energy in pursuit of development in many different sectors of Chinese society. James Scott comments that “the state’s increasing concern with productivity, health, sanitation, education, transportation, mineral resources, grain production, and investment was less an abandonment of the older objectives of statecraft than a broadening and deepening of what those objectives entailed in the modern world” (Scott, 1998:52) This increasing concern is representative of the current situation regarding China’s economic development and coal use.

During Gretchen’s Hund’s talk titled, “How to Use Coal in an Unconventional Way,” she discusses how economies are getting stronger, consuming more energy, and exacerbating the inevitable problem of global climate change. James Martin identifies the current generation as the “transition generation”(Martin, 2006). He explains that this generation will be the first to encounter the effects of global warming, thus being the ones responsible to find a viable solution. In the quiet valley of Middlebury, Gretchen spoke in front of a liberal-minded audience who seemed not to understand why China does not seek out alternate energy sources. The perception was that China seems unwilling to partake in a change where there will be little profit and the immediate benefits of a cleaner environment will not be enjoyed. Hund began by explaining China’s situation,

regarding its coal use and dependency, as a direct result of China's rapid development and its abundant, bituminous coal resources. In addition, China's government is responsible for postponing environmental studies on China's coal use and its potentially harmful effects on the environment. In doing so, the government openly admits that they are more interested in the economic development of their country than their environmental issues. They choose to alleviate poverty and strengthen their own economy, turning a blind eye to their contribution to "global" warming.

From Gretchen's discussion, China's approach to environmental issues seems to be primarily concerned with the immediate repercussions rather than the long-term ones. One example of their focus on short-term goals is the plan to limit the number of federally operated cars used in Beijing during the summer Olympics. Despite this small attempt to cap air pollution, it is not nearly enough to outweigh the damage done from the sulfur dioxides and CFCs that emit from their antiquated coal factories. The International Energy Agency Chief Faith Birol stated that, "In the past couple of months, economic growth and related coal consumption has grown at such an unexpected rate" (Greenwire.com, 2007). The exponential growth of the economy will increase the greenhouse effect and, as Greenwire states, "Unchecked, China's emissions are expected to double that of all of the members of the Organization for Economic Cooperation and Development" (Greenwire.com, 2007). The article also notes that the effect of this economic growth and coal consumption will outweigh progress made elsewhere in the world.

Chinese officials have openly admitted to delaying the release of their National Plan on Climate Change which discusses their contribution of emissions to global

warming and climate change. While Yang Ailun, a Chinese expert on climate change at Greenpeace China, agreed to the postponement of this plan, he urged government officials to respond to this problem in a “timely manner” (Greenwire.com; Greenpeace, 2007). While China should not assume full responsibility for climate change, the delay of their regulations will affect the entire world. China cannot take the issues of global warming and other environmental problems lightly. The human race has evolved and developed a technologically advanced planet and it has become “this generation’s” responsibility to use that technology to sustain and preserve our homes and future generations, just as James Martin describes in his book. Scott writes, “Technocracy, in this instance, is the belief that the human problem of urban design has a unique solution, which an expert can discover and execute” (Scott, 2007:113). While Scott warns against the dangers of “technocracy,” we must as a global society take a look into our own local communities and adaptively modify technological solutions being developed at the global scale.

The concept of metis, or local knowledge, has long been used and applied by many communities and civilizations for their own success and survival. Learned practices and skills that Native Americans used as a means of survival in remote communities are today being neglected and replaced by modern processes and new thought. The marvels of technology and industrialization have made it easier for both individuals and communities to ignore common patterns and processes that have long been taken for granted because of the availability and widespread use of modern equipment and technology that made old ways easier and more efficient. “As the older Burgis seamen said, ‘these days, with charts and compasses, *anyone* can steer’. And why not? The

production of standardized knowledge has made certain skills more broadly—more democratically—available, as they are no longer the preserve of a guild that may refuse admission or insist on a long apprenticeship” (Vaitheeswaran, 2007:335). In many circumstances, processes that are quicker and more efficient, are viewed as superior to those that are more laborious and have higher production costs. In China, newly constructed coal plants are usually based on old technology, which, while cheaper, are less efficient and have far greater environmental impacts than more expensive technology such as IGCC.

We feel that the concept of metis must be viewed more in terms of *global acquired knowledge* or *shared knowledge* rather than strictly *local knowledge* because climate change is a global problem and all communities across the globe will be affected and all communities across the globe will each play significant roles in finding solutions to combat these problems. We also see the GreenGen and FutureGen initiatives as having components of social entrepreneurship, not solely as large technological fixes.

The work of GreenGen and the optimism and general awareness of our survey participants is encouraging because it illustrates hope and acceptance for partnerships like GreenGen and the FutureGen Alliance through which metis can be incorporated into global partnerships which allow for the sharing of ideas and intellectual property. Further, environmental movements have often originated from the public sector, therefore the willingness to pay of survey participants and their strong awareness and concern for coal-related issues supports the likelihood that social entrepreneurship could significantly impact China’s progress.

REFERENCES

- Atimes.com. "Driven by Poverty, China's Coal Miners Risk All" Reporter Candy Zeng May, 2007 www.atimes.com/China_Business/IE03Cb01.html
- BBC.com. "China's Population Growth 'Slowing'" (March, 2001) www.news.bbc.co.uk/1/hi/world/asia-pacific.stm
- Balfour, F., 2005, A Big Dirty Growth Engine: Pollution Still Chokes China, but Green Technology is Starting to Emerge, 22 August, 2005. http://www.businessweek.com/magazine/content/05_34/b3948520.htm
- Bradsher, K., and Barboza, D., 2006, "Pollution from Chinese Coal Casts a Global Shadow." 11 June, 2006. <http://www.thenewyorktimes.com>
- China.org.cn "Amendment to Energy Conservation Law to Complete." 23 March, 2007. <http://china.org.cn/english/government/204109.htm>
- Clayton, M., 2007, "Global Boom in Coal Power and Emissions." Csmonitor.com. 22 March, 2007. <http://www.csmonitor.com>
- eia.doe.gov. "China: Environmental Issues." July 2003. <http://www.eia.doe.gov/emeu/cabs/shinaenv.html>
- Finkleman, Robert B, Boashan Zheng (March 1999) *Health Impacts of Domestic Coal Use in China* Proc. Natl. Academy Sci. USA Vol. 96, pp. 3427-3431 www.pnas.org
- FutureGen website: www.futuregenalliance.org. 2006.
- Ginsberg, M., 2007, Email interviews, 5/6/07-5/9/07.
- Green Car Congress. "Fiat Provides 1,000 Natural Gas Engines for Beijing Buses." 20 April, 2006. http://www.greencarcongress.com/2006/04/fiat_provides_1.html.
- Greenwire. "China to Surpass U.S Emissions this year." 24 April, 2007. <http://www.eenews.net/Greenwire/2007/04/24/archive/10/?terms=China%20to%20Surpass%20U.S%20Emissions%20this%20year>.
- Griffiths, D., 2007, "China's Mixed Messages on Climate." 7 May, 2007. <http://news.bbc.co.uk/2/hi/asia-pacific/6632399.htm>
- Hund, G., 2007, Personal Communication, (phone and in-person interviews).
- Huijts, N.M.A., et al., 2007, Social acceptance of carbon dioxide storage, Energy Policy

- Jigang, Z., 2006, The Rich Consume and the Poor Suffer the Pollution, 26 October, 2006. <http://www.chinadialogue.net/article/show/single/en/493>.
- Martin, James., 2006, The Meaning of the 21st Century, Penguin Books Ltd: USA.
- Ross, L., 1992, “The Politics of Environmental Policy in the People’s Republic of China.” *Policy Studies Journal*, Vol. 20, No. 4.
<http://www.blackwell-synergy.com/Doi/pdf/10.1111/j.1541-0072.1992.tb00187.x>
- Saiget, R.J., 2007, China Delays Release of Climate Change Report, Terra Daily: Agence France-Presse, April 24, 2007.
- State Environmental Protection Agency. <http://english.sepa.gov.cn>.
- Washingtontimes.com. “U.S. Now Third Behind ‘Made in China’”. Reporter Patrice Hill. 13 April, 2007. <http://www.washingtontimes.com>
- United Nations Economic and Social Commission for Asia and the Pacific.
“Compendium on Energy Conservation Legislation in Countries of Asia And Pacific Region.” 1 November, 1997.
<http://www.unescap.org/esd/energy/publications/compend/ceccpart4chapter4.htm>
- Yadong, Zhang, 2007, Email interview.
- Zhang, Zhong., 2007, Roots & Shoots Program Officer for Chengdu, Guest Lecturer: Environmental Studies Senior Seminar, Middlebury College, April 10, 2007.

APPENDICES

Appendix 1: Survey in English

Introduction:

We are a group of 5 college students from Middlebury College in Vermont, United States, conducting an environmental research project relating to public views on coal use in China. We really appreciate you spending ten minutes of your time to complete this survey because your responses will be very helpful in aiding our research.

1. How old are you?
2. What is your Gender?
 - M
 - F
3. Where are you from?
4. Is your home area...
 - Rural
 - Urban
 - Suburban
5. What is the energy source for the electricity in your home?
 - Coal
 - Hydro
 - Oil
 - Gas
 - Nuclear
 - Renewable
 - Other
6. Are you a university student?
7. If so, what are you studying?
8. If not, what is your occupation?
9. I am concerned about the role of energy in China's future.
 - Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
10. Environmental problems associated with coal mining concern me:
 - Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
11. I am concerned about the environmental problems associated with energy making pollution (the emissions which result from burning the coal). Strongly agree
 - Agree

- Neutral
 - Disagree
 - Strongly disagree
12. I am concerned with energy as it relates to China's economic growth.
- Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
13. Do you associate coal use with air pollution or acid rain?
- Yes
 - Somewhat
 - No
14. Do you feel like you understand the causes of global climate change and more specifically the effects of humans on the environment?
- Yes
 - No
 - Not Sure
15. Please rank your level of knowledge concerning human effects on global climate change:
- Minimally informed about effects of humans on the climate
 - Somewhat informed
 - Very knowledgeable about the effects of humans on the climate
16. Do you feel like you understand the effect burning coal has on the global environment?
- Yes
 - No
17. Please rank your level of knowledge concerning the effects of coal on global climate change
- Minimally informed about effects of coal on the climate
 - Somewhat informed
 - Very knowledgeable about the effects of coal on the climate
18. Please rank your level of concern about the effects of coal on global climate change:
- Very concerned
 - Concerned
 - Neutral
 - Unconcerned
19. How much are you currently paying for the electricity in your home?
20. If you had the option to cost-effectively switch your home energy source from traditional coal to cleaner coal, would you do it?
- Yes
 - No
21. What percentage of a price increase on your electricity bill would you be willing to pay to switch to cleaner coal energy?
- None

- 1-5%
 - 5-10%
 - 10-15%
 - Other
22. How would your parents answer the previous question?
- None
 - 1-5%
 - 5-10%
 - 10-15%
 - Other
23. Would you be more willing to switch to the cleaner coal use if you saw successful implementation of its technologies in other counties?
- Yes
 - No
24. Under whose supervision would you be most willing to switch to energy from cleaner coal technology?
- State control
 - Private industry
 - Coordinated international efforts
 - Other
25. If you had the option to cost-effectively switch your home energy source from traditional coal to an alternative source such as small scale methane production, hydro power or solar energy, would you do it?
- Very likely
 - Likely
 - Neutral
 - Unlikely
 - Very unlikely
26. What percentage of a price increase on your energy bill would you be willing to pay to switch to small scale methane production, hydro or solar energy for heating and electricity in your house?
- None
 - 1-5%
 - 5-10%
 - 10-15%
27. How would your parents answer this question?
- None
 - 1-5%
 - 5-10%
 - 10-15%
 - Other
28. What drives your decision to switch to cleaner energy sources? (Choose all that apply)
- I wouldn't switch
 - Moral obligation to reduce green house gases

- Concern about health effects from traditional coal
 - Economic decision because China could then trade carbon credits in a worldwide carbon market
 - Other
29. Do you feel there is an urgency to switch to cleaner energy sources?
- Yes
 - No
30. Were you aware that 70% of China's energy comes from coal?
- Yes
 - No
31. Do you have friends or family involved in the coal industry?
- Yes
 - No
32. How significant do you feel the health effects of coal use are in China?
- Not very
 - Somewhat
 - Very
33. Please rank your personal views on the use of coal in China
- Approval
 - Could use improvements
 - Disapproval
34. GreenGen is a network of Chinese scientists and industries involved with researching ways to build cleaner coal processing facilities. Have you heard of GreenGen?
- Yes
 - No
35. How did you learn about GreenGen
- Internet
 - Media
 - School
 - Word of Mouth
 - Other
36. How optimistic are you about the possibility for GreenGen and others to innovate cleaner coal technologies?
- Very optimistic
 - Optimistic
 - Neutral
 - Not Very Optimistic

Appendix 2: Survey in Chinese

明德大学FutureGen 小组针对中国大学生的调查问卷

简介:

我们是美国佛蒙特州明德大学(Middlebury College) 由五位本科生组成的研究小组。目前我们正在进行一项关于中国民众对国内煤矿使用情况意见的环境学术研究。我们真心希望并感谢您用约十分钟时间填写以下调查问题。您的回答将给我们的研究带来极大的帮助。谢谢!

1. 请问您的年龄是?

2. 请问您的性别是?

- ☐ 男
- ☐ 女

6. 请问您是哪里人?

7. 请问您的家乡在...

- 乡村
- 城市
- 城市郊区

8. 请问您家里电力来源是?

- 煤炭
- 水能
- 石油
- 煤气
- 核能
- 可再生能源
- 其他_____

6. 请问您是在校大学生么?

7. 如果是 您主修什么专业?

8. 如果不是 您的职业是?

请问您对以下陈述的看法:

9. 我关心能源问题对中国将来发展的影响:

- 强烈同意
- 同意
- 中立
- 不同意
- 强烈不同意

10. 与煤矿有关的环境问题牵涉到我个人: :

- 强烈同意
- 同意
- 中立
- 不同意
- 强烈不同意

11. 我关心与开发能源造成的污染(注释: 具体说煤炭燃烧放出的气体) 有关的环境问题:

- 强烈同意
- 同意
- 中立
- 不同意
- 强烈不同意

12. 我关心能源问题 因为它关系到中国的经济发展: .

- 强烈同意
- 同意
- 中立
- 不同意
- 强烈不同意

13. 请问您会将煤矿的发展利用和空气污染或者酸雨联系在一起么?

- 会
- 有一些
- 不会

14. 请问您认为自己明白全球变暖的原因 更具体地说人类对环境的影响么?

- 是

- 不是
- 不确定

15. 请评价您对关于人类对环境的影响的知识了解情况

- 我对关于人类对环境的影响的知识有很小程度的了解
- 我对其有些了解
- 我对其非常了解

16. 请问您认为自己了解煤炭使用对全球气候的影响么？

- 是
- 不是

17. 请评价您对关于煤炭使用对全球气候的影响的知识了解情况:

- 我对关于煤炭使用对全球气候的影响的知识有很小程度的了解
- 我对其有些了解
- 我对其非常了解

18. 请评价您对煤炭使用对全球气候变化影响的关心程度

- 非常关心
- 不确定
- 不关心

19. 请问您家目前平均每人每月负担的电费大约多少？

20.

如果您可以选择以较划算的价格将家庭电力来源从传统煤炭转换成较为清洁的煤炭，您会这样选择么？

- 会
- 不会

21. 如果决定做出这样的改变，您可以接受电费有大多程度的上涨？

- 完全不接受涨价
- 1-5%
- 5-10%
- 10-15%
- 其它

22. 请问您父母大概会如何回答以上的问题？

- 完全不接受涨价
- 1-5%
- 5-10%
- 10-15%
- 其它

23. 如果您见到这项技术在其他国家的成功实现，您是否会更加愿意选择使用更清洁的煤炭？

- 是
- 不是

24. 在哪一方的技术监督管理下您最愿意选择使用清洁煤炭处理技术？

- 国家监督
- 私人企业
- 国际合作的努力
- 其它

25.

如果您可以比较经济划算的将家庭电力来源从传统煤炭改换到其它可替代能源，比如说小规模沼气生产，水能或是太阳能，您会这样选择么？

- 非常可能
- 有可能
- 中立
- 不大可能
- 没有可能性

26. 如果将家庭电力暖气来源改换成以上提到的可替代能源，您愿意接受电费单多大程度的上涨？

- 不接受涨价
- 1-5%
- 5-10%
- 10-15%

27. 请问您父母大概会怎样回答上面的问题？

- 不接受涨价

- 1-5%
- 5-10%
- 10-15%
- 其它

28. 请问以下哪些因素驱使您决定选择使用更清洁的能源? (请选择所有合适的)

- 我不愿意改变
- 减少温室气体排放的道德义务
- 对传统煤炭对身体健康影响的担心
- 纯经济方面的考虑: 鉴于全球范围内有对各企业每年所排放的温室气体多少的定额 如果我们可
以成功减少排放的温室气体的量 中国可以将多余的定额卖给别的国家和地区从而获益。
- 其它

29. 请问您觉得目前有迫切的需要换用更清洁的能源么?

- 是
- 不是

30. 请问您之前了解中国70%的电力来源于煤炭么?

- 是
- 不是

31. 请问您是否有在煤炭产业工作或者与其有关联的亲戚或朋友?

- 有
- 没有

32. 您认为在中国煤炭使用对人类身体健康的影响有多严重?

- 不太严重
- 有些严重
- 非常严重

33. 请选择您对中国煤炭使用情况的个人看法:

- 同意
- 可以有更多的改善
- 不同意

34.

GreenGen是一个由多位中国科学家和企业通过调查研究来发展较清洁煤炭处理设备的组织。请问您是否听说过GreenGen?

- 是
- 不是

35. 如果是 您是如何了解到GreenGen的?

- 因特网
- 媒体
- 学校
- 聊天中听说
- Other

36. 请问您对GreenGen或其它组织创新发展清洁煤炭处理技术的前景有多乐观?

- 非常乐观
- 乐观
- 中立
- 不大乐观

感谢您牺牲您的宝贵时间回答我们的调查问卷！谢谢！

Appendix 3: Survey Results

How old are you?	
Total Respondents	30
(skipped this question)	0
What is your Gender?	
	Response Total
M	18
F	12
Total Respondents	30
(skipped this question)	0
Where are you from?	
Total Respondents	29
(skipped this question)	1
Is your home area...	
	Response Total
Rural	6
Suburban	11
Urban	14
Total Respondents	30
(skipped this question)	0
What is the energy source for the electricity in your home?	
	Response Total
Coal	6
Hydro	1
Oil	2
Gas	7
Nuclear	2
Solar	1
Not sure - the National Electric Grid	15
Total Respondents	30
(skipped this question)	0

Are you a university student?	
	Response Total
Yes	20
No	10
Total Respondents	30
(skipped this question)	0
If so what are you studying?	
Total Respondents	20
(skipped this question)	10
If not what is your occupation?	
Total Respondents	10
(skipped this question)	20
I am concerned about the role of energy in China's future:	
	Response Total
Strongly agree	20
Agree	8
Neutral	1
Disagree	0
Strongly disagree	0
Total Respondents	29
(skipped this question)	1
Environmental problems associated with coal mining concern me:	
	Response Total
Strongly agree	19
Agree	7
Neutral	3
Disagree	0
Strongly disagree	0
Total Respondents	29
(skipped this question)	1

I am concerned about the environmental problems associated with energy making pollution (the emissions which result from burning the coal).	
	Response Total
Strongly agree	22
Agree	7
Neutral	0
Disagree	0
Strongly disagree	0
Total Respondents	29
(skipped this question)	1
I am concerned with energy as it relates to China's economic growth.	
	Response Total
Strongly agree	17
Agree	11
Neutral	1
Disagree	0
Strongly disagree	0
Total Respondents	29
(skipped this question)	1
Do you associate coal use with air pollution or acid rain?	
	Response Total
Yes	26
Somewhat	3
No	0
Total Respondents	29
(skipped this question)	1
Do you feel like you understand the causes of global climate change and more specifically the effects of humans on the environment?	
	Response Total
Yes	25
No	0
Not Sure	4
Total Respondents	29
(skipped this question)	1

Please rank your level of knowledge concerning human effects on global climate change:	
	Response Total
Minimally informed about effects of humans on the climate	1
Somewhat informed	15
Very knowledgeable about the effects of humans on the climate	9
Total Respondents	25
(skipped this question)	5
Do you feel like you understand the effect burning coal has on the global environment?	
	Response Total
Yes	26
No	3
Total Respondents	29
(skipped this question)	1
Please rank your level of knowledge concerning the effects of coal on global climate change	
Minimally informed about effects of coal on the climate	1
Somewhat informed	18
Very knowledgeable about the effects of coal on the climate	7
Total Respondents	26
(skipped this question)	4
Please rank your level of concern about the effects of coal on global climate change:	
Very concerned	12
Concerned	11
Neutral	2
Unconcerned	0
Total Respondents	25
(skipped this question)	5

How much are you currently paying for the electricity in your home?	
Total Respondents	21
(skipped this question)	9
If you had the option to cost-effectively switch your home energy source from traditional coal to cleaner coal would you do it?	
	Response Total
Yes	25
No	0
Total Respondents	25
(skipped this question)	5
What percentage of a price increase on your electricity bill would you be willing to pay to switch to cleaner coal energy?	
	Response Total
None	0
1-5%	5
5-10%	12
10-15%	6
Total Respondents	25
(skipped this question)	5
How would your parents answer the previous question?	
	Response Total
None	6
1-5%	7
5-10%	3
10-15%	5
Total Respondents	25
(skipped this question)	5

Would you be more willing to switch to the cleaner coal use if you saw successful implementation of its technologies in other counties?	
	Response Total
Yes	23
No	2
Total Respondents	25
(skipped this question)	5
Under whose supervision would you be most willing to switch to energy from cleaner coal technology?	
	Response Total
State control	11
Private industry	6
Coordinated international efforts	5
Other (please specify)	2
Total Respondents	24
(skipped this question)	6
If you had the option to cost-effectively switch your home energy source from traditional coal to an alternative source such as small scale methane production hydro power or solar energy would you do it?	
	Response Total
Very likely	14
Likely	9
Neutral	0
Unlikely	2
Very unlikely	0
Total Respondents	25
(skipped this question)	5

What percentage of a price increase on your energy bill would you be willing to pay to switch to small scale methane production hydro or solar energy for heating and electricity in your house?	
	Response Total
None	1
1-5%	4
5-10%	14
10-15%	5
Total Respondents	24
(skipped this question)	6
How would your parents answer the previous question?	
	Response Total
None	6
1-5%	6
5-10%	5
10-15%	3
Other (please specify)	3
Total Respondents	23
(skipped this question)	7
What drives your decision to switch to cleaner energy sources? (Choose all that apply)	
	Response Total
I wouldn't switch.	0
Moral obligation to reduce green house gases	21
Concern about health effects from traditional coal	16
Economic decision because China could then trade carbon credits in a worldwide carbon market	7
Other (please specify)	2
Total Respondents	25
(skipped this question)	5
Do you feel there is an urgency to switch to cleaner energy sources?	
	Response Total
Yes	23
No	2

Total Respondents	25
(skipped this question)	5
Were you aware that 70% of China's energy comes from coal?	
	Response Total
Yes	18
No	7
Total Respondents	25
(skipped this question)	5
Do you have friends or family involved in the coal industry?	
	Response Total
Yes	5
No	20
Total Respondents	25
(skipped this question)	5
How significant do you feel the health effects of coal use are in China?	
	Response Total
Not Very	0
Somewhat	8
Very	17
Total Respondents	25
(skipped this question)	5
Please rank your personal views on the use of coal in China	
	Response Total
Approval	2
Could Use Improvements	14
Disapproval	9
Total Respondents	25
(skipped this question)	5

GreenGen is a network of Chinese scientists and industries involved with researching ways to build cleaner coal processing facilities. Have you heard of GreenGen?	
	Response Total
Yes	1
No	24
Total Respondents	25
(skipped this question)	5
How did you learn about GreenGen?	
	Response Total
Internet	0
Media	0
School	0
Word of Mouth	1
Other (please specify)	0
Total Respondents	1
(skipped this question)	29
How optimistic are you about the possibility for GreenGen and others to innovate cleaner coal technologies?	
	Response Total
Very optimistic	3
Optimistic	11
Neutral	7
Not Very Optimistic	4
Total Respondents	25
(skipped this question)	5

Appendix 4: Interview Questions and Transcripts

Zhang Yadong

Hi, Colleen

Glad to hear from you. I had submitted the answer on line many days ago. It's a great questionnaire. And also, I share them with many boys. May be they have done it too.

What about the "Chinese version"? You would like me to translate the questions to Chinese? It must be difficult. However, it's be ok in English, because that we all study English several years and can done it without Chinese.

Best regards!

Zhang Yadong
Green Longjiang

Greenpeace China's Climate Change Division

Questions for Interview:

1. To see what they know about coal: Current coal technology in use?
2. New technologies? → do you campaign for clean coal or just renewables?
3. National Plan on Climate Change delayed—any updates? Can you tell me more about it?
4. What is the public awareness of environmental issues in China? Climate change? Coal issues?
5. What is the role of the government? Private sector/ businesses? NGO's? Academics?
6. Role of Olympics and environmental problems
7. Al Gore's movie?
8. Media coverage?

Notes from interview:

- no specific data on public awareness
- government may have research from at least 7 years ago....nothing recent
- ACM has data?
- Many people know about climate change/ global warming because they can feel it happening, but they don't have the urgency to act on it
- Global warming: people in cities aware, but no motivation→ Both people don't know how to reduce CO2 and they don't feel that they personally can make a difference
- → they think the cars they drive are leading to climate change and people are contributing to climate change but they can't find a specific source of that – they don't actually realize how much they can personally contribute to the reduction of CO2—hard to realize as a common citizen—situation is similar as in the U.S., maybe, because there is not such awareness
- china has many environmental problems as they are still a developing country: water pollution and other issues→ don't pay as much attention to global warming and climate change, they have many other things to worry about (food security= top concern)
- coal issue: no direct linkage from coal use to climate change...more linkage to lungs and cancer or pollution like acid rain, but not climate change

- china is trying to use new technologies for coal...many, many new technologies- international institutions like World Bank are trying to introduce some kind of technology to China
- **Greenpeace believes that no coal can really be clean – don't accept the idea of clean coal—ultimately it is dirty and translated into CO2**
- Greenpeace doesn't know what caused the National Climate Change Plan delay/postponement – no concrete reason for it
- It is supposed to cover many environmental issues in general, not only about GHG's
- Role of government/NGOs/etc: Chinese NGO's do gain more momentum on these issues but the govt. makes the decisions...NGOs ask more and more of the government...they ask to be active consultants for the govt.
- Does the government take your advice and make new regulations quickly or is it a slow process?→ she doesn't know how to judge the pace of making regulations... organizations like Greenpeace and Energy Foundation are both involved in the drafting of the new renewable energy laws, which were published in 2006 → Govt. will listen to the experts' opinions
- Academia's role: ES major in Chinese universities? Yes, there is an ES major—both ES students and other students are aware of environmental issues
- Olympics: China has a chance to be more international and welcome the world to see how China is international—important window to show that China is getting modernized and environment is also one of the very important aspects of that international standard.
- Al Gore's movie: the Greenpeace China team has seen it—still not extensively shown in China, but for current students that are environmentally conscious have already seen it
- In general, media coverage of environmental issues is increasing- it is an important portion of newspaper coverage
- How does Greenpeace work to try to improve awareness of environmental issues? They publish reports and have concerts to engage more people—they are pretty effective

Mark Ginsberg, Department of Energy's Office of Energy Efficiency and Renewable Energy Board of Directors

Questions:

- What issues have you run into with your meetings on energy efficiency? What was the goal of these meetings? Who participated?
- "I was wondering what you thought about the recent postponement of China's National Plan on Climate Change (allegedly due to political disputes over the impact such a plan could have on the economy). More specifically, I was wondering who it is you are working with in China (obviously very broad - a powerful lobby? government? private sector?) and what obstacles they face to implementing the use of biofuels and battery technologies?"

Answers:

- "On energy efficiency, China has set an ambitious goal of reducing energy consumption per GDP by 20 percent by 2010. That is driving a very high interest in energy efficient construction, building codes, appliance standards and labeling and industrial energy. In addition, China is very interested in reduced dependency on oil and is exploring with us biofuels and battery technologies. These are on-going discussions and I'm not sure what is in public documents."
- "Sorry again, but I'm not so familiar with a postponement. On biofuels and batteries, we are in discussions with the National Development Reform Commission (NDRC). I think they face the same obstacles we do on market economics, some research needs, consistent standards and infrastructure. The price and availability of oil for relatively

inexpensive gasoline is true all over the world. On biofuels, we are conducting research on cellulosic ethanol which would move us away from food-based crops. There are international discussions on harmonizing biofuel standards and certification to assure quality. And of course, infrastructure needs to adjust to ethanol (E-85, for example, requires hardened engine parts and delivery systems.)

Representative of the China Huanang Group [wishes to remain anonymous] (contact for FutureGen and GreenGen)

Questions for interview:

1. Tell us about GreenGen
2. What is GreenGen's role in China?
3. Public awareness of GreenGen and climate change
4. What is the relationship between FutureGen and GreenGen? Competition? Collaboration?
5. What is the motivation of GreenGen?
6. If clean coal is more expensive for the average person's electricity, do you think people will be willing to pay for it?
7. Does public opinion matter?

Notes from interview:

GreenGen is almost the same as FutureGen (follower), but GreenGen is working in stages.

1st stage: it install a pilot station of IGCC to gasify coal (use their own technology developed in Chinese research institutes)

2nd stage: hydrogen turbine for electricity generation

3rd stage: capturing sequestration in CO₂

FutureGen will use hydrogen directly- like fuel cells

- they receive 0% funding from FutureGen
- GreenGen tries to develop and test the technologies by Chinese institutes....I think this means that they want China to be very involved
- They do collaborate with international corporations though...example Siemens, GE
- Collaboration with FutureGen, not competition
- FutureGen is non-profit and GreenGen is non-profit
- GreenGen is a pilot project
- China wants to develop these technologies to develop capacity of China (again, not too sure what this means, but I think it means that china doesn't want to be left in the dust...they want the technologies too?)
- The process for approval of this type of project is not as complex of a process as it is in the U.S.
- There are similar projects to G.G and F.G all around the world
- G.G is not on schedule with the first step of their project (it was projected for 2010, but not going to happen.) He seemed to think this is because they are a developing country and they are not too confident with technology yet. However, they are going to try as hard as they can to get the first step completed on time
- Regarding the projects, there is no awareness in china of GG, people don't pay much attention- GreenGen is trying to let people know more about it.
- In circles of government and industry the popularity of GG is quite high....this is only the very beginning
- He thinks that it would be good to install educational facilities around the project to increase awareness

- Regarding climate change: he thinks that awareness is growing very fast these days for several reasons: china had a very warm winter and as a result, people started talking about climate change
- Al Gore's movie is a big hit with people and students that know English
- The public majority/ major public is not well informed/educated
- Media comes from the govt and research institutes → limited to what they say
- Not a big private sector, NGO's not that big in general—govt and research institutes biggest factor

Prices:

- There will be increased electricity prices with clean coal
- Electricity prices are controlled by government- they try to keep it reasonable → less profit for power generation—no incentive for outside companies to try to compete with cleaner technology
- Cost of coal is increasing
- Govt: asked companies for technology for SO₄ → consumer prices of coal increased
- China's Clean Air Act (SEPA) even stricter than the U.S.'s: all new power projects must comply with clean air regulation.

2nd Interview

Questions for interview:

1. FutureGen is hoping to use deep saline formations to sequester carbon- what is GreenGen going to use?
2. Is GreenGen developing their own IGCC or are they getting the technology from another company?
3. Are there political incentives to use new coal technology?
Are there economic incentives?
If no, what is the motivation for GreenGen?
4. Where does GreenGen plan to get all of the water needed for new coal technology? Use waste water?
5. I read in the news that China has postponed the release of the "National Plan on Climate Change." Does this effect GreenGen?

Notes from Interview:

- GreenGen will sequester carbon in used oil fields or deep saline formations like FutureGen, experts know how to identify the geology formations
- GG first stage: gasification, not include carbon capture and sequestration (CCS)
- FutureGen does both in one plant
- GG: own technology for IGCC in China- developed by Chinese research institute because cheaper than using international technology- in order to control the cost of the equipment
- FutureGen: buy technology/equipment for gassifier from international companies (GE or Seimens)
- Economic motivation to use new coal technology
- National Plan on Climate Change postponed: won't affect GG, GG will move forward
- GG: ~5 years for gasification, + 5 more years for carbon sequestration
- lack of water resources in areas where coal is abundant -- get around water problem by possibly using air cooling technology instead of water or transport coal to another area
- power project sometimes invest money to improve local water resource systems, such as irrigation systems, to save water from irrigation to use for the power plant/ industry
- the areas up north are not very developed...room to improve water conservation
- Institutes: "thermal power research institute" owned by China Huaneng group, which is owned by the state → institute indirectly owned by state
- Universities: also active in doing research

Randy Kritkauskys, President of ECOLOGIA

China's population is very diverse and public access to information is extremely varied, from almost none to well-informed. I am certain that the vast majority, 95%+ will have no idea of coal and its relation to climate change. When I did an internet search for GreenGen, the first website was porno photos from u-tube. It was a real effort for me to obtain any information about this company and initiative. It will be nearly impossible from the Chinese side.

Casie Davidson, geologist

Questions for the Interview:

After returning from China...

1. Did you find that there are viable deep saline formations in China in which CO₂ can be sequestered? Storage capacity?
2. Are they close to the power plants or would there be a pipeline?
3. Was the water issue discussed as a limiting factor?
4. Gretchen said that you told her that the university doesn't know about GreenGen- can you elaborate on overall knowledge of GreenGen? FutureGen?
5. Who specifically did you work with to compile the geology data?
6. Do you give that info to FutureGen? Where does the compiled info go?

Notes from interview:

- Casie spent a week in China researching the CO₂ storage capacity within the geologic formations of China.
- Deep, saline formations that are viable for carbon sequestration in China: she believes that there are quite a few of them
- She worked with a partner from the Institute of Rock and Soil Mechanics in Wuhan—he has done a lot of digging in the literature, but a problem in China is that there is not a lot of published data. The data that is out there is from petroleum companies but is very scattered and luck of the draw if you find it
- Even if a power plant is sitting on top of one of these deep saline formations, it might not be the best place to inject the CO₂ → common to use pipelines to transport the CO₂ to a better formation—very rare to put a CO₂ well right next to the power plant, unless you are really lucky
- In China there seems to be in places a mismatch between where the storage formations are and where the coal reserves/sources are
- NW of the country there are hardly any sources of CO₂ because water is very difficult to get for a power plant or a ccl (?) facility or some sort of industrial facility in which the processor requires a huge amount of water → you could never put one of these industrial processors there because the very little water that is in this region is used for drinking and irrigation – but they have giant storage formations for CO₂
 - o Even more advanced technology to use dry cooling or something to conserve the water resources would be needed → then, NW China would be a really good place to have a power plant and CO₂ storage right next to each other and then transmit the power where it is needed
 - o But right now, it looks as if the NW China might be a resource that nobodies going to be able to tap for quite some time because there are no sources of CO₂ (power plants) up there
- Other places: lots of sources of CO₂ but not the CO₂ storage capacity

- Ex: Japan has a lot of sources but not storage capacity—it would benefit from China sequestering as much as possible, maybe even more than it needs—**Japan could then buy the offsets from China**
- → “China has **most** of what it needs in **most** of the right places”...for anything not in the right place, pipelines can be used

Waste Water:

- FutureGen is likely to demonstrate that waste water can be used (2 of its 4 planned sites would use waste water) =sewage water that has been treated and put back out that is actually clean enough to drink (but obviously no one wants to drink it!)
- The waste water option is being looked into more and more as water resources are declining, especially in places where a high percentage of ground water is being used for drinking and irrigation—treat it and use it for something productive instead of just putting it back into the ground
 - Waste water in NW China? So sparsely populated now, but may not stay that way—technological advances may be made that make the region more hospitable to live in—china’s population trends are really shifting, hard to predict where people will move
 - Beijing water: regular water not even drinkable- brushed her teeth with bottled water – using waste water in a city like Beijing may not be as simple as using waste water in the U.S. (our waste water may be cleaner than their drinking water)
- People doing energy work in China and people doing water work are going to need to start working together

University awareness of GreenGen (Tsinghua University):

- People close to the central government and folks that are the movers and shakers of the climate change and energy modeling world at the biggest university in Beijing have heard of FutureGen, but weren’t aware that the China Huaneng group was one of the partners and had **never heard of** GreenGen (talked to brand new early career professors)
- Is there an ES program in Chinese universities? Yes, but grad school is where you learn the most
- Geology data that she was gathering not actually compiled yet—China is a very touchy place to do climate change research right now- China was supposed to release its National Plan on Climate Change a couple of weeks ago –they put it off and then release a press statement that they will not release the plan any time in the near future
 - China doesn’t believe that they should be the one tackling this problem right now (climate change) – they have a lot of issues to deal with, esp. economic development that they need to be moving forward with
 - They want the west to step up first before they commit to anything
 - This effects anybody doing climate change research in China right now, Casie included
 - Casie trying to make sure her project is still on track- treading water at the moment
 - Most electricity companies are under the governmentt→ new technology come to a halt? China is very excited about CDM (?) stuff/ projects- they want foreign investors to come in and build China new power plants to the extent that companies are willing to do that to meet their Kyoto targets or whatever → China is happy to have them come and build new stuff – but the current party line right now is that they are not going to do CO2 reduction for CO2 reduction’s sake
 - In the cases that they think they can make some money on it, EOR (enhanced oil recovery) or enhanced coal and methane recovery, then

- they are willing to do it if the west is willing to pay them money to do it – but the attitude is largely “okay, but what’s in it for us”
- China is a place of dichotomies right now: very capitalist pockets (oil and gas development going on, a lot of free market activity (Beijing)) but the government is still very much centrally planned
 - Ex: to get the 2008 Olympics, Beijing committed to meeting World Health Organization air quality targets by the time the Olympics start – in order to do that the government has been shutting down the entire iron and steel industry in the capital (every iron and steel plant within ~30 miles of the city) → closed the doors, tore them down and moved them ~250 km south of the city – China can do that because it is centrally planned
 - China also has a mandate on the books (which might not even happen) they’ve limited the number of conventional coal power plants, but the people are building them any way (happening all over China)
 - Supposed to be an electricity dispatch law that says that only the most efficient power facilities can get dispatched, so the idea is that anything under 50 MW would be shut down → but so much demand for electricity right now that production is already overtaxed, so to shut down a bunch of plants or dispatching only the most efficient ones is ridiculous
 - The government has a lot of plans but there is not much political will to actually do them – unless the west is going to cough up some sort of incentive, China is not interested...it wants to focus on economic development and pulling its people out of poverty
 - No release of China’s National Plan on Climate Change: NY Times, Greenwire
 - Casie’s work is not for FutureGen, it’s for a different project (Casie works for Battelle) – her info doesn’t go to FutureGen and she doesn’t think FutureGen cares necessarily— they are just focused on building their plant in the U.S.
 - FutureGen cares about global climate change politics in a high-level peripheral way
 - After FutureGen builds their plant in the U.S., will the technology be used abroad or is that strictly dependent on who buys the technology? -- up to whoever buys the technology, info shared in the professional community
 - China is very interested in the technology, but they are interested in other people paying to put the technology in China
 - She doubts that the Chinese govt would fund an IGCC with CCS – the only reason they would fund one is if they think it would be better for them in the long run efficiency-wise or better for air quality standards (they don’t really care about CO₂) – concerned about what immediately affects the people and everything else= “we don’t have the luxury to worry about those problems right now”
 - If FutureGen is successful and there is enough political will in the west to fund things like a FutureGen in China, then China would be thrilled to have them
 - “The country’s electricity producers lack the economic and political incentives to break from their traditional practices. In contrast, large-scale efforts to produce liquid transportation fuels using coal gasification are well under way.” (Technology Review published by MIT)
 - People are getting cars like crazy in China—can’t get more oil, so need another source of liquid transportation fuels → increase in CTL (coal to liquid) facilities
 - Gasification alone is not the same thing as gasification with CCS → these gasification plants turn out huge quantities of CO₂—enormous impact on

nation's CO2 amount – burn CO2 to get the coal to a liquid fuel, then burn the fuel in cars → even more CO2

- Could use CCS with this type of gasifier, but it is expensive...China won't do it on its own but probably would if the west paid them to do it
- Are the big gasifier companies (GE and Siemens) doing anything to come up with CCS technology? – Casie hasn't heard anything from them about it – they found research to appear green, but she doesn't think they are doing anything in sequestration per say
- All the electricity companies are **very** closely tied to the government
- Called a central government, but so many factions within it with their own agendas
 - National Plan on Climate Change: spent all the time and money on this report that talked about the impacts of climate change and what China needs to do to address it and what the timeframes are like and how it would cost them if they didn't address it → someone thought it was important to do, someone else thought its release should be postponed → a lot of internal politics going on right now and hobbling the country in regards to the climate change policy plans
- SEPA (Clean Air Act) but nobody enforces it...can't build more dirty coal power plants but nobodies enforcing that → laws on the books, but if nobody enforces them the people think they are a joke
- The government owns a million cars within the city of Beijing
- Even if they reach the World Health Organization air standards for the Olympics, it will probably only last until the end of the games—people can't drive for the 3 weeks during the Olympics
- The country really wants to be wealthy and westernized, but still so much poverty
- Plug and abandon practices for wells in the U.S.- important for reliable cap rocks used for CCS – China doesn't have any info on the wells on private land, nothing plugged → sequestration only after remediation of old wells → very expensive
- Government can sensor research, stop it before it starts
- Real drive to westernize

Christopher Williams, NRDC

Hello Ms. Sullivan,

I am sorry that it has taken so long for us to get back to you on your question; I hope you understand how busy this time of year can be. Here is what we have been able to find out specifically about your questions.

Strictness of China's Clean Air Act:

As represented by the chart compiled by Yi, Hao, and Tang (2007): 908 (see attached paper), it appears that China's National Ambient Air Quality Standards are more stringent than those established by the USEPA National Ambient Air Quality Standards, except in the field of PM10.¹ However, due to the major implementation problems exist in the Chinese context, it may be appropriate to state that although Chinese ambient air quality regulations are as strict as, if not stricter than, American air quality standards, Chinese law has less real ability than that of the US to force social actors to change behavior. China's implementation problems are widely agreed upon to be based in such factors as the generalist tone of national laws, the system of responsibility sharing between national and sub-national governments, lack of citizen

¹ Honghong Yi, Jiming Hao, and Xiaolong Tang. "Atmospheric environmental protection in China: Current status, developmental trend and research emphasis" *Energy Policy* 35(2007): 908.

participation, lack of staffing at environmental protection bureaus, lack of monitoring facilities, local protectionism, and a weak judicial system.

However, some municipalities have taken proactive steps to making air quality better, especially Shanghai, Beijing, and Guangdong. These cities, like other local level governments in China, are able to make regulations in their jurisdictions stronger than those set nationally, as long as the national laws are not contravened or weakened in any way. Doing so with increased monitoring, fines, and standard levels has led to dramatic improvements in single source air emissions in recent years.

Implementation of China's Atmospheric Pollution Laws takes place in a similar fashion to the system of enforcement in the US: namely, enforcement officials, upon discovering a malfeasance, generally inform the firm in noncompliance of the finding and investigate further. A warning is issued in the great majority of cases, and this warning is often accompanied by a time limit set for coming into compliance. Fines and taxes on the emissions may also be levied at this time. In the case of firm resistance, bureaucratic actors in China are likely to take the case to their superiors to gain political weight for enforcement. Court is seen as a last resort, as it endangers intergovernmental and personal relationships, is costly in time and staffing resources, and is often less fruitful than pursuing less formal forms of dispute resolution.

Strictness of Agenda 21:

China's Agenda 21 plan and implementation has come under fire from international critics who say that China has followed the letter of the law in establishing a lengthy (200+ page) implementation plan, but with little monitoring and enforcement capabilities to back this implementation plan up. This appears to be consistent with China's signing of, and implementation of, other international environmental treaties.² As you state, finding updates on the state of China's implementation of Agenda 21 is difficult to say the least; it strikes me that this dearth of information is perhaps because there is no real implementation of China's Agenda 21 aside from the basic steps taken to get an implementation policy on the books.

Effectiveness of Clean Air Act:

Yi, Hao and Tang state that "Atmospheric environmental quality in China has been improving due to a variety of programs implemented by the Chinese government in recent decades."³ However, they state that, "[...]air pollution is still serious because of rapid socioeconomic development and increased energy use."⁴ Importantly, the trend to be discerned in China's development trajectory is that although the majority of China's atmospheric pollution continues to originate in the power generation sector, increasingly sources are mobile or associated with

² See Economy and Oksenburg's discussion of China's signing and compliance with CITES, the London Convention, the World Heritage Convention, the International Tropical Timber Agreement, and the Montreal Protocol in Michael Oksenburg and Elizabeth Economy. "China: Implementation under economic growth and market reform" in Edith Brown Weiss and Harold K. Jacobson (eds.) *Engaging Countries: Strengthening Compliance with International Environmental Accords* (Cambridge, MA: MIT Press, 2000) 353- 394.

³ Honghong Yi, Jiming Hao, and Xiaolong Tang. "Atmospheric environmental protection in China: Current status, developmental trend and research emphasis" *Energy Policy* 35(2007): 907.

⁴ Id.

non-power generation facilities.⁵ This development does not bode well for China's current system of regulation implementation. China's air laws and standards, as well as implantation agendas, have traditionally been geared towards a community's most visible polluter; thusly, small scale TVEs (although collectively the strongest growing sector of China's economy since the reform period) have been largely ignored in the pursuit of implementing either water or air quality laws. Rather, SOEs (state owned enterprises) and international joint ventures have more often times been the target of enforcement campaigns.

Thus, the majority of gains made in pollution control due to the China's Atmospheric Pollution Law has been made by enforcement campaigns aimed at large firms; which is rational in that these are low hanging fruits, but this pattern has led to a situation where the current enforcement expertise built up in EPBs, that of enforcing laws on large scale firms, is inadequate to solve the problems of cleaning up small and mobile sources of emissions.

Another enforcement strategy used by the Chinese government is enforcement campaigns, which establish size and compliance quotas for jurisdictions and orders the executives of the jurisdiction to shut down all firms which do not meet the minimum requirements. However, van Rooij has noted that these campaigns are often far from 100% implemented, and firms often restart, rebuild, or move elsewhere, continuing with the same polluting behaviors as before.

Effectiveness of Agenda 21?

Although little of the relationship between air quality and Agenda 21 has been discussed by Western scholars, considering the lack of effective implementation of China's own air laws, it seems unlikely that the central government would emphasize Agenda 21 over more immediate needs such as fixing national law implementation. I would argue that this perspective is in accordance with the popular view of China as disinterested, due to sticky issues of national sovereignty, in discussing implementation rates and strategies when it comes to international environmental agreements of which it is a signing member.

Relationship of Clean Air Act to coal fire power plants?

I would argue that although some plants have been retrofitted with sulfur dioxide scrubbers to bring them into compliance with emissions limits, and some coal is being washed before burning, China's clean air regulations are only effective in reducing pollution when implementation and enforcement can be assured at much higher rates than average. Thus, SO2 scrubbers are most often installed during campaigns which bring higher level officials to sites to see implementation occurring. It is often noted that factories turn off the pollution control equipment once oversight officials have left.

A more dramatic effect on coal fire power plants, I would say, would be the fact that many have been moved out of big cities in recent years. It is notable, however, that these power plants are often merely reassembled *en mass* wherever they are sent to; thus little progress is made in the way of actually reducing global emissions, however local air quality in cities is improved.

⁵ Id.

Relationship of Agenda 21 to coal fire power plants?

I found nothing even tangentially related to this. The only other thing that I can think of, but did not look into, is these new sustainable community trial projects we keep hearing about are probably not run by coal fire generated power. However, it may be the case that some of the electricity for these communities is still generated by remote coal plants. I doubt very much, in any case, that Agenda 21 has had any effect on China's building an average of 2.5 coal fire power plants a week; this however is conjecture.

Public awareness of pollution from coal?

I think that people are aware that coal emissions are bad for them; recent reports from Linfen (a coal capital, as it were) indicate that most people in these communities are perfectly aware of the negative effects of coal on their health. Please see:

www.npr.org/templates/story/story.php?storyId=10221268

Less is known publicly, it would seem, about water effluent from coal washing. Although methane is a major contributor to global climate change, methane emissions from coal mining are only talked about when mine explosions occur. Additionally, I have heard only very little about free-burning coal piles, none of which came from the Chinese press. However, mine accidents are mentioned frequently in the news and subsidence prevention is a national priority. For more on the public awareness of pollution problems in general, please see:

http://news.xinhuanet.com/english/2007-01/16/content_5611577.htm.

Public support for clean coal technologies?

I would argue that the public's main concern with coal is the cost; i.e. the cheaper, the better. As clean coal technologies are expensive, they are less likely to garner the wide-spread affirmative support by the public unless subsidies are granted to cheapen the cost for the average consumer. To the average person in urban China, I feel that coal is quite like a rich and very disagreeable uncle. You put up with its bad parts in order to reap the enormous gains to be had by using it as much as possible.

Effect of the Olympics on China's energy infrastructure and use of coal?

The movements of the Beijing government towards Olympics preparedness can be thought of as a more urgent and higher stakes version of classical enforcement campaigns. Not only have heavily polluting firms and coal fire power plants been moved out of the city with great expediency, but similar firms are also being vigorously cleaned up or moved in the surrounding 5 provinces, as well. Little is being done, however, to reduce energy use in Beijing or these other places, which would seem like a more reasonable option than just picking up and moving house. Coal in private homes has been phased out in Beijing already for some time, and the government continues efforts to gradually get rid of all coal-fire boilers and equipment used in the city. However, coal and coal gas is still used in many private homes.

Through which avenue cleaner coal can be implemented on a larger scale in China?

I really don't know about this one, actually. There is only one coal gasification plant going up right now that I know of, and its small scale (300 MW I believe). This is compared to the 100+ GW added to the national grid last year. I believe there are some other gasification plants either already built or in development, but surely, they constitute a very, very small drop in a large

ocean; but it's a start. Some CoGen is going on, but not much. Money seems to be an issue of central importance. Also, I suspect that most current projects were planned, it seems, during the real estate boom of recent years, which has now subsided slightly. Thus, these plants are already on the books and the financing is already there. Often times, these coal plants get pushed through the approval process without actually producing an Environmental Impact Assessment, a necessary step according to national law. Although some projects have been caught and closed down due to this, even these projects have started back up, in some cases producing a retroactive EIA, in some cases not. It would seem that, based upon the rare frequency of even this minimal level of enforcement, the actual cases of malfeasance must be much greater (a fair hypothesis, considering China's implementation track record). Thus it can be imagined, if not assumed, that many coal plants going up right now are not going through the proper approval procedures before being built. Thus, the opportunity to make a convincing argument for cleaner coal based upon the ecological necessity of the technology may very well fall on deaf, or at least very uneducated, ears.

Good luck with you paper. Again, I apologize for the lateness of this response. Please feel free to contact me with questions if you would like further assistance. My email is Williams.christopher.j@gmail.com.